Entergy

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NL-16-104

September 14, 2016

U.S. Nuclear Regulatory Commission
Document Control Desk
11545 Rockville Pike, TWFN-2 F1
Rockville, MD 20852-2738

SUBJECT: Licensee Event Report # 2015-004-01, "Automatic Reactor Trip Due to a Turbine-Generator Trip Caused by a Failure of the 31 Main Transformer"
Indian Point Unit No. 3
Docket No. 50-286
DPR-64

Reference: 1. Licensee Event Report # 2015-004-00, letter NL-15-080, dated July 8, 2015

Dear Sir or Madam:

Pursuant to 10 CFR 50.73(a)(1), Entergy Nuclear Operations Inc. (ENO) hereby provides Licensee Event Report (LER) 2015-004-01. The attached LER is a revision to an LER submitted by Reference 1, that identified an event where the reactor automatically tripped, which is reportable under 10 CFR 50.73(a)(2)(iv)(A). As a result of the reactor trip, the Auxiliary Feedwater System was actuated, which is also reportable under 10 CFR 50.73(a)(2)(iv)(A). The transformer failure resulted in an explosion and fire and an Unusual Event was declared which was reportable under 10 CFR 50.72(a)(1)(i). As a result of the transformer fire, transformer insulating oil spilled onto the transformer yard and mixed with fire protection deluge water. This deluge water/oil mixture then spilled over into the site storm drain system and into the plant discharge canal which made its way to the Hudson River. The oil spill was reported to the National Response Center and other government agencies which was reportable under 10 CFR 50.72(b)(2)(xi). This condition was recorded in the Entergy Corrective Action Program as Condition Report CR-IP3-2015-02913. A detailed inspection and failure analysis of the 31 MT was performed to identify the failure mechanism and root cause. As a result of degraded unplanned scrams performance indicator, further evaluation was performed and a revised root cause evaluation issued. Changes as a result of the equipment failure evaluation and additional evaluations are included in this LER revision.

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There are no new commitments identified in this letter. Should you have any questions regarding this submittal, please contact Mr. Robert Walpole, Manager, Regulatory Assurance at (914) 254-6710.

Sincerely,

AJV/cbr

cc: Mr. Daniel H. Dorman, Regional Administrator, NRC Region I
NRC Resident Inspector's Office, Indian Point Energy Center
Ms. Bridget Frymire, New York State Public Service Commission

NRC FORM 366 (01-2014) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104 EXPIRES: 01/31/2017

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records and FOIA/Privacy Service Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects.resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

1. FACILITY NAME:	2. DOCKET NUMBER	3. PAGE
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4. TITLE: Automatic Reactor Trip Due to a Turbine-Generator Trip Caused by a Failure of the 31 Main Transformer

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV. NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
5	9	2015	2015	- 004 -	01	9	14	2016		05000
									FACILITY NAME	DOCKET NUMBER
										05000

9. OPERATING MODE

1

10. POWER LEVEL

100%

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☐ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☒ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

NAME	TELEPHONE NUMBER *(Include Area Code)*
Tom O'Connor, Engineering Systems-Electrical	(914) 254-5837

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
X	EL	XFMR	S843	Y					

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

16. ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced type written lines)*

On May 9, 2015, an automatic reactor trip (RT) occurred due to a Turbine-Generator trip as a result of a failure of the 31 Main Transformer (MT). All control rods fully inserted and all required safety systems functioned properly. The plant was stabilized in hot standby with decay heat being removed by the condenser. There was no radiation release. The emergency diesel generators did not start as offsite power remained available. The auxiliary feedwater system actuated as expected due to steam generator low level from shrink effects. Control room operators received alarms on the fire detection panel of the activation of the 31 MT and curtain wall deluge valves. Report to operators that there was an explosion and fire on the 31 MT. The plant fire brigade responded to the fire. The 31 MT had failed. Due to collateral influence from the 31 MT failure, the deluge system for the 32 MT and Unit Auxiliary transformer had also activated. In accordance with the emergency plan a Notice of Unusual Event (NUE) was declared at 1801 hours, which was terminated at 21:04 hours. The direct cause was an internal fault of the A Phase high voltage winding in the upper portion of the transformer. The root cause was vendor design/manufacturing deficiency that caused an internal failure that resulted in a fault on the A phase HV side of the transformer and the A phase HV voltage bushing. Key corrective actions included replacement of the 31 MT with a spare transformer, associated acceptance testing, repair of the isophase bus ducting for the 31 MT, inspections, cleaning, testing of the 32 MT, the Unit Auxiliary Transformer, high voltage components, isophase buses and main generator. A 4-year PM was prepared to perform Partial Discharge testing on the Unit 2, and Unit 3 MTs, Unit 2 and Unit 3 Auxiliary Transformers and the Unit 3 GT Auto Transformer The event had no significant effect on public health and safety.

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NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

Note: The Energy Industry Identification System Codes are identified within the brackets {}.

DESCRIPTION OF EVENT

On May 9, 2015, with the unit at 100 percent reactor power, an automatic reactor trip (RT) occurred at 17:50 hours, due to a Turbine-Generator trip as a result of a failure of the 31 Main Transformer (MT){XFMR}{EL}. All control rods [AA} fully inserted and all required safety systems functioned properly. The plant was stabilized in hot standby with decay heat being removed by the condenser {SG}. There was no radiation release. The emergency diesel generators {EK} did not start as offsite power remained available. The auxiliary feedwater system {BA} actuated as expected due to steam generator {AB} low level from shrink effects. Control room operators received alarms on the fire detection panel of the activation of the 31 MT and curtain wall fire protection system {KP} deluge valves. Operators received a report that there was an explosion and fire on the 31 MT. The plant fire brigade was activated and responded to the fire. The 31 MT had failed along its bottom weld seam resulting in most of its insulating oil draining from the transformer tank. Due to the collateral influence from the 31 MT failure, the deluge system for the 32 MT and Unit Auxiliary transformer had also activated. Water from the deluge systems mixed with transformer oil and overflowed the transformer containment structure and entered the site storm drainage system which outfalls to the Hudson River. The Unit 3 Operations Shift Manager declared a Notice of Unusual Event (NUE) in accordance with the Emergency Plan Emergency Action Level (EAL) HU 2.2 at 18:01 hours, due to the 31 MT fire and explosion effecting plant equipment. The NUE was terminated at 21:04 hours. An investigation into the cause of the event and a post transient evaluation was initiated. The event regarding the 31 MT fire and RT was recorded in the Indian Point corrective action program (CAP) as Condition Report CR-IP3-2015-02913.

On May 9, 2015, the 31 MT experienced a low impedance ground fault on the 345 kV A Phase. The 31 MT Differential Phase A (87/T21A) and the Differential Phase A and B relays (87/GTA and 87/GTB) actuated initiating a turbine trip and RT via the Main Generator Primary and Back-up Lockout relays 86P and 86BU. The Primary and Back-up Ground Fault and Phase Fault detector relays also actuated. Investigation of the event determined that data from the fault recorder [Disturbance Monitoring Equipment (DME)], relay targets and visual inspection of the failed transformer confirmed that an A Phase fault initiated the event. Based on inspection data, it appears the transformer experienced a rapid increase in pressure due to the failure originating in the A Phase. The sudden pressure increase caused the transformer tank to fail in multiple locations. Combustible gases from arcing built up in the transformer as the insulating oil leaked from the tank breach. The main transformer tank also failed along the bottom weld seam resulting in most of the oil draining from the tank. The hot oil and gases ignited and caused an explosion and fire.

The main generator supplies electric power at 22 kV through an isolated phase bus to two MTs. The MTs step up the voltage to 345 kV and transmit the electric power to the Buchanan substation south ring bus. The 31 MT {XFMR} was manufactured by SMIT Nymegen {S843} Serial Number 219805 in 1988 and commissioned for use as a spare transformer in 1989. This unit replaced the original MT in 2007. The SMIT transformer had F&G Type OTFA Style HV bushings (number 1050/362-2000). An on-line gas monitoring system is installed on each main transformer. The failed 31 MT was a three phase, natural circulation, forced air cooled, Conservator oil system, power transformer rated for 22 kV/345 kV operation at 607 MVA. The HV leads are brought out of the transformer through bushings in the cover of the transformer tank.

Transformer cooling is provided by oil naturally circulating in two banks of radiators with a total of 24 fans. The 31 MT is one of two main generator output transformers designed to step up the three phase 22 kV output by the generator to 345 kV for power transmission to the electric power grid. The MTs are within transformer moats which are passive concrete structures that are designed to contain the volume of oil in the transformer to preclude a potential oil release to the environment.

During the 31 MT fire, the fire protection system deluge system associated with the 31 MT, 32 MT, UAT and the wall curtain (adjacent Turbine Building) were actuated. Based on design of the deluge system for the transformer yard, only one deluge system actuation is anticipated. However, for this event due to the collateral influence from the 31 MT failure and fire, the deluge system associated with the 32 MT and UAT were also actuated. These concurrent actuations resulted in an overload of the moat system. Approximately 22 minutes after deluge system actuation operations directed the deluge to be secured.

The work history of the failed SMIT 31 MT installed in 2007 was that it was maintained as a spare until the original 31 MT failed. Before installation the three HV Felten and Guilleaume (F&G) bushings were satisfactorily tested and installed on the 31 MT. In 2009, the neutral ground bushing was replaced to repair an oil leak. During that outage, electrical testing revealed an evaluated power factor for 31 MT low voltage (LV) X1 and X6 bushings. In 2011 all six LV bushings were replaced, In 2013, a condition assessment analysis was performed on the 31 MT by Doble engineering. The main tank of the 31 MT was drained for internal inspection, bolting was tightened and LV bushing gaskets were replaced with Viton material. The A phase H1 HV F&G bushing was replaced because its power factor nearly doubled and exceeded the recommended limit. The 2013 Doble condition assessment report included that the DGA results indicated that the intermittent hot metal gas generation started after the LV bushing replacement in 2011 and was active when the transformer was removed from service. The gassing condition was most likely due to lack of proper grounding, lack of bonding or use of inadequate materials in areas of the LV bushings but no cause was identified. IPEC tightened the bolting on the LV bushings' internal connections and the top shielding of the core and coil clamping frame and replaced LV bushing gaskets. After returning to service after the 2013 outage, gassing had not been eliminated. Additional monitoring showed gas production rates did not exceed adverse levels. During the 2015 outage, Power Factor and Capacitance, Excitation Current, Winding Resistance, Insulation Resistance, and Leakage Reactance testing were performed attempting to detect internal faults. Test results showed all tests completed successfully and within limits. Also performed was Sweep Frequency Response Analysis (SFRA) to evaluate the mechanical integrity of the core, windings and clamping structures which were found within limits. The transformer oil was reprocessed. Entergy consulted with the transformer manufacturer SMIT providing oil samples and electrical testing results. SMIT recommended an internal inspection which was performed in 2013 with transformer experts but were unable to identify the cause of the gassing. Due to elevated gas in 2014, Entergy contacted world industry experts, experts from SMIT, Exelon and all agreed no tank entry was warranted.

An extent of condition investigation identified other high voltage power transformers (Unit 3 MT-32, Unit 2 and 3 Unit Auxiliary Transformers, Unit 2 MT-21 and MT-22 and the Unit 2 and 3 Station Auxiliary Transformers) that have a high risk of a high or low voltage fault. The other transformers are manufactured by different companies. MTs 21 and 22 and the new 31 MT are manufactured by Siemens. Unit 3 MT-32 is manufactured by General Electric, and the Unit 2 and 3 UATs are manufactured by Westinghouse. Risk is based on transformer age. There is no existing condition or degradation of component reliability on any of Indian Point's large power transformer assets that would require any immediate actions.

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The Cause of Event

The direct cause of the RT was the 31 MT Differential Phase A and the Unit 3 Differential Phase A and Phase B relays actuated initiating a Turbine Trip/Reactor Trip via Main Generator Primary and Back-up Lockout Relays 86P and 86BU. The Primary and Back-up Ground Fault and Phase Fault detector relays also actuated. The direct cause of the 31 MT failure was an internal, high energy fault of the A phase high voltage (HV) portion of the transformer.

The root cause was vendor design/manufacturing deficiency that caused an internal failure that resulted in a fault on the A phase HV side of the transformer and the A phase HV voltage bushing. An offsite facility performed a detailed forensic teardown and inspection of the coil assemblies and bushings and were unable to determine the location of the initiating A phase HV fault. Localization of a possible fault initiation site on or within the A phase HV coil was made impossible by the damage. During teardown examination, it was determined the A phase bushing sustained a radial electric fault in the area where operating stresses are the greatest. However, it could not be determined if this was the initiating fault. The 31 MT failure was caused by a high energy fault in the transformer that resulted in arcing, rapid heating, and formation of gaseous decomposition products from cellulosic material and mineral oil that filled the transformer tank. The initiating fault that caused the pressurization occurred in the A phase winding or bushing, with one being the likely consequence of the other. The testing, maintenance, and monitoring that was being performed prior to the failure was thorough and consistent with industry standards. There was no indication in the test results that the occurrence of failure was imminent and could have been prevented.

Corrective Actions

The following are some of the corrective actions that have been or will be performed under the Corrective Action Program (CAP) to address the causes of this event.

- The failed 31 MT was replaced with a spare transformer, acceptance tested and placed in service.
- The isophase bus ducting for the 31 MT was repaired and the associated buses inspected and tested, inspections, cleaning, testing was performed on the 32 MT, Unit Auxiliary Transformer, high voltage components, and main generator.
- A detailed inspection and failure analysis of the 31 MT was performed to identify the specific failure mechanism and root cause.
- A teardown failure analysis of A phase windings and A phase HV bushing was performed.
- A 4-year PM was prepared to perform Partial Discharge testing on the Unit 2, and Unit 3 Main Transformers, Unit 2 and Unit 3 Auxiliary Transformers and the Unit 3 GT Auto Transformer.
- Include increased factory and site acceptance testing for new or on order large power transformers similar to guidance found in procedure 2-XFR-006-ELC Section 5.2. Action is to verify transformer purchase specification details specific factory testing and that contracts also stipulate specific site testing.
- The remaining 32 MT manufactured by GE is scheduled to be replaced in 2019 by a Siemens transformer of the same model as the other three installed transformers.

Event Analysis

The event is reportable under 10CFR50.73(a)(2)(iv)(A). The licensee shall report any event or condition that resulted in manual or automatic actuation of any of the systems listed under 10CFR50.73(a)(2)(iv)(B).

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NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

Systems to which the requirements of 10CFR50.73(a)(2)(iv)(A) apply for this event include the Reactor Protection System (RPS) including RT and AFWS actuation. This event meets the reporting criteria because an automatic RT was initiated at 17:50 hours, on May 9, 2015, and the AFWS actuated as a result of the RT. On May 9, 2015, at 18:26 hours, the following notifications were made in accordance with 10 CFR 50.72: a 1-hour emergency class notification of an unusual event (NUE) under 10 CFR 50.72(a)(1)(i), a 4-hour non-emergency notification for an actuation of the reactor protection system {JC} while critical under 10 CFR 50.72(b)(2)(iv)(B), a 4-hour notification for notification of other government agencies for an event related to the protection of the environment due to the transformer oil spill under 10 CFR 50.72(b)(2)(xi), and an 8-hour notification under 10CFR50.72(b)(3)(iv)(A) for a valid actuation of the AFW System (Event Log #51060). As all primary safety systems functioned properly and there was no safety system functional failure reportable under 10CFR50.73(a)(2)(v).

Past Similar Events

A review was performed of previous Licensee Event Reports (LERs) reporting a RT as a result of main transformer failure. Unit 3 LER-2007-002 reported a RT on April 6, 2007, as a result of a fault on the 31 MT Phase B High Voltage bushing. The cause was a design weakness associated with the type bushing used in the Phase B bushing. The cause of the event reported in LER-2007-002 was not similar to the current MT failure as this failure was associated with the transformer A Phase high voltage winding not the bushings. Unit 2 also experienced a RT due to a failure of the 21 MT on November 7, 2010 as reported in LER-2010-009. The cause of that failure was due to an internal failure of the B Phase bushing as a result of a manufacturing/design deficiency.

Safety Significance

This event had no effect on the health and safety of the public.
There were no actual safety consequences for the event because the event was an uncomplicated reactor trip with no other transients or accidents. Required primary safety systems performed as designed when the RT was initiated. The AFWS actuation was an expected reaction as a result of low SG water level due to SG void fraction (shrink), which occurs after a RT and main steam back pressure as a result of the rapid reduction of steam flow due to turbine control valve closure.

There were no significant potential safety consequences of this event. The RPS is designed to actuate a RT for any anticipated combination of plant conditions to include low SG level. The reduction in SG level and RT is a condition for which the plant is analyzed. A low water level in the SGs initiates actuation of the AFWS. Redundant safety SG level instrumentation was available for a low SG level actuation which automatically initiates a RT and AFWS start providing an alternate source of FW. The AFW System has adequate redundancy to provide the minimum required flow assuming a single failure. The analysis of a loss of normal FW (UFSAR Section 14.1.9) shows that following a loss of normal FW, the AFWS is capable of removing the stored and residual heat plus reactor coolant pump waste heat thereby preventing either over pressurization of the RCS or loss of water from the reactor. This event was bounded by the analyzed event described in FSAR Section 14.1.8 (Loss of External Electrical Load). All components in the RCS were designed to withstand the effects of cyclic loads due to reactor system temperature and pressure changes.

For this event, rod control was in manual and all rods inserted upon initiation of a RT. The AFWS actuated and provided required FW flow to the SGs. RCS pressure remained below the set point for pressurizer PORV or code safety valve operation and above the set point for automatic safety injection actuation. Following the RT, the plant was stabilized in hot standby.